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ABSTRACT

A listing of awards made by the Division of Science Education Development and Research (SEDR) of the National Science Foundation (NSF) during fiscal year 1980 and 1981 and selected related projects supported in earlier years is presented. All references made to actual award amounts are noted as subject to adjustment by financial statements prepared by NSF at the close of fiscal years reviewed. It is noted that purchase orders, funds for personnel as provided in the Intergovernmental Personnel Act, and International Travel Awards are excluded from the report. The document opens with a discussion of pre-college mathematics using computers, which looks at: (1) the role of the National Science Foundation; (2) changes that are possible; (3) the projects; and (4) the future. This portion considers questions such as: (1) What are some of the substantive improvements in the mathematics curriculum that the computer makes possible? (2) Can young children learn mathematics using computers? and (3) What new equipment seems to be useful? The bulk of the document is devoted to a presentation of project summaries. The table of contents refers to projects alphabetized first by states, and then by institutions within each state. (MP)

NATIONAL SCIENCE FOUNDATION
Education Development

DEVELOPMENT IN SCIENCE EDUCATION

Pre-College Mathematics Education Using Computers

Project Awards Fiscal Years 1980 and 1981 and Selected Related Projects Supported in Earlier Fiscal Years

This report presents a listing of awards made by the Division of Science Education Development and Research (SEDR) during fiscal years 1980 and 1981 and earlier years. All references made in this document to actual award amounts are subject to adjustment by financial statements prepared by NSF at the close of fiscal years 1980 and 1981 and in these earlier years.

Division-initiated funding actions excluded from this report are:

Purchase Orders
Funds for Personnel (Intergovernmental Personnel Act)
International Travel Awards

Awards which received support from organizations within or outside the Division show the source of that support.

The following definitions apply:

"Award" refers to financial support given in the form of a grant, a contract, or other arrangement, depending upon the nature of the research or development work to be completed and the terms of performance.

"Principal Investigator" refers to the individual designated by the awardee (and approved by NSF) who is responsible for the scientific or technical direction of the project.

"Institution" refers to any college, university, public or private laboratory, industry, or other organization, whether operating for profit or on a non-profit basis, as well as State and local governments and Federal organizations.

Note: Data for this report were taken from program records and therefore may differ from official National Science Foundation source documents which are generated from the Management Information System data base containing different inclusions/exclusions.

The reader is reminded that the primary source of further information on a project is the Principal Investigator in each instance, who may be reached at the academic address given.

FOREWORD

In the last few decades, the basic sciences have produced an avalanche of new information and technology. However, our nation's ability to convert that information into useful knowledge that will benefit society will depend in large measure upon the ability of our citizens to function effectively in an increasingly scientific and technological world. It is becoming imperative that we have a population educated in science, mathematics and, increasingly, in the understanding of computers.

The National Science Foundation Act of 1950 (as amended) specifically includes the provision in Sec. 3.(a)(4) that the Foundation is "to foster and support the development and use of computers and other scientific methods and technologies, primarily for research and education in the sciences." It is in fulfillment of this function that the high-leverage projects described in this book have been supported by the Foundation's Science and Engineering Education Directorate. They are representative of our efforts to assist education in the United States to meet the needs and opportunities of the age of information.

Walter L. Gillespie
Acting Assistant Director for Science
and Engineering Education

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Pre-College Mathematics Using Computers

Mathematical skills are viewed by society as an important indicator of the quality of education that our nation's school children are receiving. Declining national test scores bring newspaper headlines proclaiming concern for the quality of education; rising scores tend to reassure a concerned public about the wise investment of tax dollars.

However, for our young people who are to become future scientists, engineers, and technicians, mathematical skills are analytical tools prerequisite to the mastery of these increasingly complex professions. Young people are the human resources that are vital in maintaining and improving the industrial base that supports a healthy nation and a strong economy.

Since World War II mathematics has been joined by a new analytical tool in business, industry, government and the military—the computer. The use of the computer is having profound effects on all of these segments of our society. The computer does things faster, and by doing things faster it transforms the way we are able to think about the activities themselves.

But the computer which is in the process of changing so much of our society has, thus far, had little impact on our schools. Dr. J.C.R. Licklider of M.I.T. says, in a national study of Technology in Science Education, "Education is not only missing a great opportunity, it is failing to discharge a responsibility."[1]

American education is just beginning to incorporate the computer into instruction in larger numbers. In the last three years, the low price and easy accessibility of the microcomputer have motivated even financially distressed school districts to spend their own money to enter the computer age. A recent report from the National Center for Educational Statistics indicates, however, that the primary use for the computers presently in the schools is for computer literacy.[2] As yet the computer has not become the primary tool of mathematics.

Many leading mathematicians, computer scientists and educators believe that the computer will dramatically affect what students need to learn in pre-college mathematics. Examples—exemplars—of what changes these might be are the subject of this volume.

[1]Licklider, J.C.R., "Technology in Science Education: The Next Ten Years," National Science Foundation, July 1979, U.S. Government Printing Office, GPO 038-000-00432 ($2.50), p. 3.

[2]National Center for Educational Statistics, "Student Use of Computers in Schools," U.S. Department of Education, Room 620, Presidential Building, 6525 Bellcrest Road, Hyattsville, MD 20782.

The Role of the National Science Foundation

The National Science Foundation has the mission, under its Organic Act (P.L. 81-507), to improve the health of science and science education in the United States. For over twenty years, NSF's Development in Science Education Program and its predecessors have been supporting experimental computing projects in science, mathematics, and engineering education. This booklet, which focuses on pre-college mathematics and computing, provides summaries of these projects supported in Fiscal Years 1980 and 1981 and highlights some of the projects supported in earlier years. It is the Foundation's role to offer a variety of different approaches among which state and local groups may choose, if they wish to do so.

The Changes that are Possible

What are some of the substantive improvements in the mathematics curriculum that the computer makes possible?

The spatial and dynamic qualities of mathematics can be emphasized. The spatial and dynamic aspects of mathematics are some of the most difficult for students to master. When studying geometry, the computer can offer the student the ability to create an object on the screen, to turn it and view it from any angle. These capabilities promise significant improvement over a textbook in which the student sees only stationary objects and is required to imagine how they might change as a result of an event or, at best, imagine how the object changed from one illustration to another.

Algorithmic reasoning can be exercised and tested. The result of the National Assessment of Educational Progress (NAEP) makes it clear that while students perform well on basic arithmetical operations (addition, subtraction, etc.) their abilities to handle complexity—to solve problems, to understand a problem and to choose an appropriate method for solving it—are declining. A prelimimary study by Clement, Lochhead and Soloway at the University of Massachusetts indicates that writing computer programs to find solutions to problems helps the student to improve his problem-solving abilities through creating an appropriate design and interacting with the computer to test the quality of the solution.[3]

The usefulness of mathematics can be demonstrated more readily. The usefulness of mathematics is often difficult to

[3]Clement, John, Jack Lochhead, and Elliot Soloway, "Cognitive Processes Involved in Algebraic Symbolization," Cognitive Development Project, Dept. of Physics and Astronomy, U. of Masschusetts, Amherst, MA 01003, July 13, 1979.

understand, especially by those students less inspired by traditional mathematics instruction. Creating computer music and art, however, which demonstrate or utilize the underlying mathematical concepts in these creative efforts, helps to build an understanding of mathematics as a sophisticated language—a tool to facilitate communication.

How can the computer also enhance our ability to teach mathematics?

Using a computer makes possible the introduction of mathematical ideas at earlier ages. Introductory statistics, for example, used to be considered an undergraduate or advanced high school course chiefly because of the cumbersome data-handling techniques rather than the complexity of the statistical ideas. The concepts of statistical surveys and data collection and analysis which many children enjoy can now be studied, for example, in middle school using the computer to actually manipulate the data.

The computer can enhance the mathematics learning environment by enabling the student to generate and solve problems. The speed of the computer lets the student do more homework problems in a given time period. The computer can also be used to give the student help in the basic arithmetic skills through drill and practice.

What other conditions are necessary to realize these improvements?

Identifying diverse, innovative, promising and successful new approaches is a crucial part of the challenge. Innovative strategies require the attention of the educational community—parents, teachers, state and local government and professional societies—before improvements can be available to many school children.

During the summer of 1981, regional meetings were held around the United States. Representatives of many of the projects in this booklet and other experts discussed these projects and other innovative activities and tried to predict what changes could and should be expected in the next ten years, given the availability of computers. At a final retrospective gathering which included representatives from all four meetings, the participants stated that in addition to creative ideas, the following conditions were also necessary before a real improvement in mathematics education could be realized:

High quality reliable hardware, software and courseware are needed in sufficient quantities in schools if computing is to have an educational impact. Hardware that works consistently, software that is easy to use and reliable, and large quantities of high quality courseware are all needed so that the computer can be used consistently and productively by all teachers and students.

Educators—teachers, administrators, school boards—need to be informed and educated in these enhancements and changes in mathematics education and in the use of the computer itself (computer literacy).

Support structures must be created or fortified to offer assistance and continuing education for teachers in the classroom. Teachers need continuing support in the use of hardware and software (telephone hot lines or "800" numbers to experts, for example) and continuing assistance on creative and effective ways to use the computer in class.

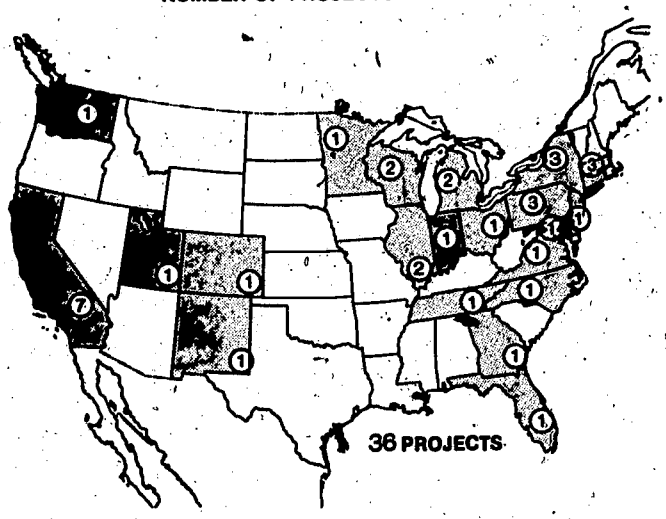
The knowledge and potential of this approach to mathematics education should be available to all citizens. Knowing both mathematics and computing provides access to high level jobs and professions. All of our citizens should have access to these new skills.

The Projects

All of the 36 projects funded in FY 80 and FY 81 emphasize the development of prototypes of courseware for teaching, learning, and doing mathematics. While only merit (not geography) was considered in awarding the grants, these projects are being conducted throughout the United States, as can be seen in Figure 1.

Figure 1

FY 1980 AND FY 1981
PRE-COLLEGE MATHEMATICS USING COMPUTERS
NUMBER OF PROJECTS BY STATE



The projects suggest a series of questions that the community is pondering, and a number of areas for further research and development.

What topics in mathematics attract experimentation?

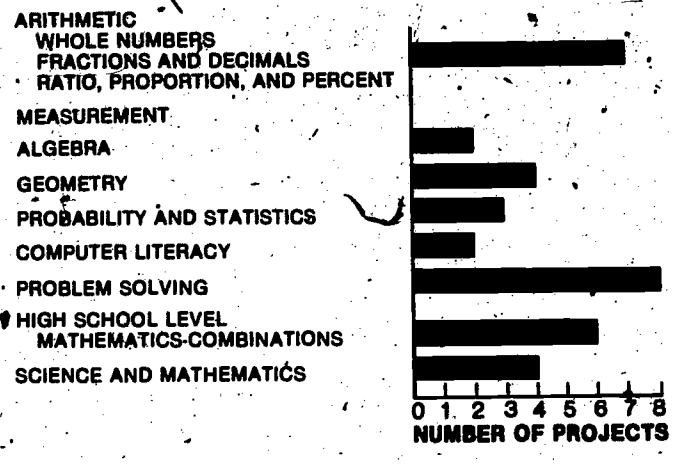
The first seven categories of Figure 2 are based on the categories of mathematics used in a report from the National Council of Teachers of Mathematics, *Priorities in School Mathematics* (PRISM).[4] The mathematical topics chosen by the projects reflect the high priorities of the school community. The large number of projects in arithmetic responds to the stress on basic skills. Measurement

[4] *Priorities in School Mathematics*: Executive Summary of the PRISM Project, National Council of Teachers of Mathematics, Inc., 1906 Association Drive, Reston, Virginia 22091, 1981, p. 1.

is addressed in portions of one or two projects but is not the primary interest of any of them.

Figure 2

FY 1980 AND FY 1981
PRE-COLLEGE MATHEMATICS USING COMPUTERS
PROJECTS BY TOPIC



Eight projects are working on problem solving, and the National Council of Teachers of Mathematics Agenda for Action (Recommendation 1) stresses problem solving as one of the most important activities for mathematics education in the '80's.[5]

The category, high-school-level mathematics combinations, includes projects which are attempting to discover the most useful ways of incorporating computer graphics in trigonometry, geometry, algebra and even arithmetic. These projects are trying to weave the computer into the high school mathematics curriculum in places where students or teachers have special difficulties in teaching or learning mathematics.

Can young children learn mathematics, using computers? Ten years ago the conventional wisdom was that a 4th grader was the youngest child that could use computers effectively. Microcomputers with color and sound have changed things a lot. Three projects (Piestrup, Kraus, Gattegno) are working with children in the first three grades.

William Kraus at Wittenberg University is working on a strategy for using the game of golf to teach estimation of angles and lengths. Figure 4 illustrates the golf game. The lower righthand corner of the screen indicates the quadrants of the circle and the angles 0, 90, 180, and 270. The black line above the word "how" is the length of the units to be estimated for the distance of the drives and putts. The game can be played with up to four players. Both placement and numbers of sand traps and water hazards vary with each game. Placement of the tee and green is also varied.

[5] *An Agenda for Action: Recommendations for School Mathematics of the 1980s*, National Council of Teachers of Mathematics, Inc., 1906 Association Drive, Reston, VA 22091; pp.; 2-5.

Preliminary results indicate that very young children can become "mathematics-ready" and can learn mathematics by using computers.

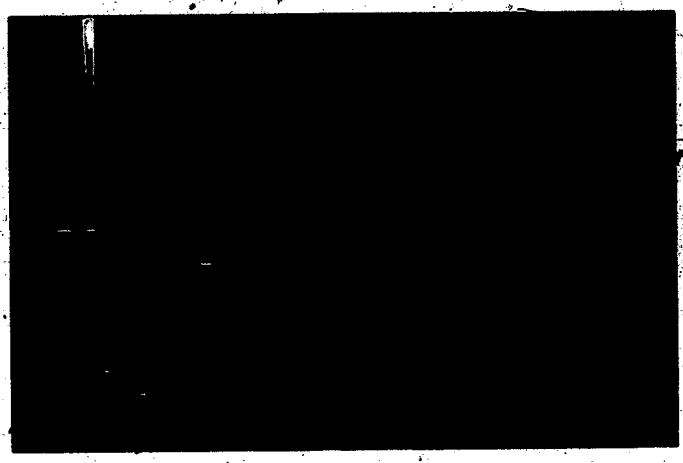


Figure 3. Ann Piestrup at Advanced Learning Technology is creating geometry courseware for 2nd and 3rd graders.

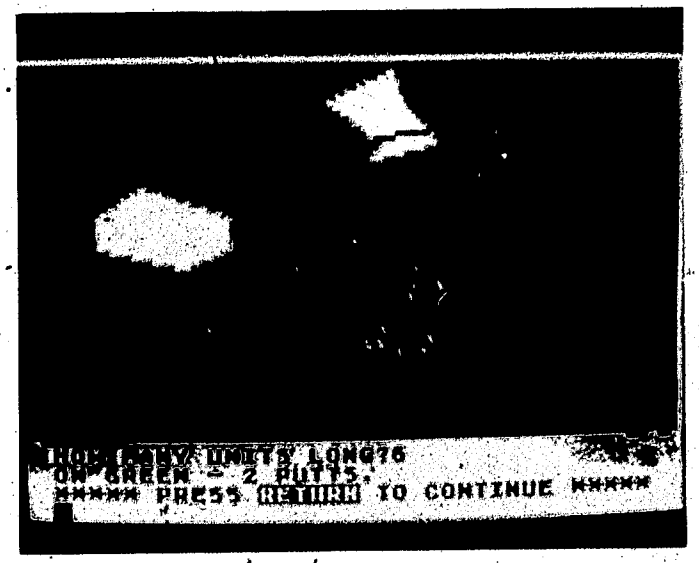


Figure 4. William Kraus uses a golf game to teach students to estimate length and angles.

Will interactive graphics improve learning? For whom? Many of these projects are conducted in urban schools; they involve many minorities and are concerned with the problems women have experienced historically in learning mathematics. Adults are the focus of projects at Virginia Commonwealth University and the University of California at Santa Barbara; and adults will be part of the field-test populations of other projects.

The computer is a promising vehicle for making mathematics more accessible and understandable for a greater proportion of the population than succeeded in mathematics using just a teacher, textbook and the traditional classroom.

Figure 5. Judith Hakes is developing simulations of energy use for late elementary grades at the All-Indian Pueblo Council.

Figure 7. Judah Schwartz's project at the Education Development Center, Inc. explores mathematical word problem solving in contexts interesting to junior high school students. Both print and microcomputer-based materials are being developed.

Can students improve their abilities to solve problems? The term "problem solving" covers a wide variety of topics. The current interest in problem solving includes the mathematical statement or word problems of the past. It also includes decision-making skills and procedures and real-world problems in which there may be more than one correct answer to the problem. One of the goals is to help students to learn good methods for identifying, analyzing and solving problems. The computer can illustrate the situation with moving graphics or (if a videodisc is used) with still or moving pictures of the event. The student can explore and experiment by getting feedback from the computer before deciding which solution is appropriate. The problems can also have realistic numbers rather than numbers chosen to "come out even."

Figure 8

HARDWARE CHOSEN BY PRINCIPAL INVESTIGATORS

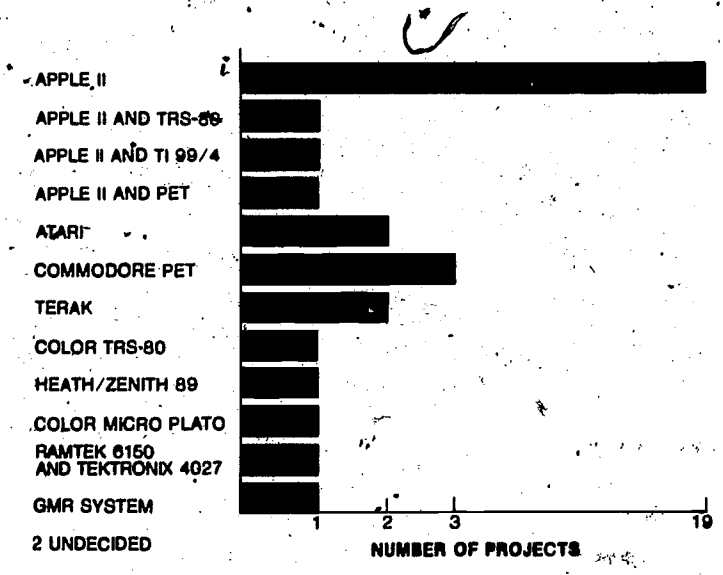


Figure 6. Mary Grace Kantowski at the University of Florida is working on both mathematical and "real-world" problem solving for grades 5 through 12.

What new equipment seems to be useful? A change in the brand of equipment proposed is rarely suggested by the Program; it was not suggested on any of these projects.

A major concern is whether or not we can effectively create courseware for the next five or ten years using the relatively limited equipment found in classrooms today. Are these the best tools with which to do exploratory work?

Encouraging grantees to use the microcomputer of the future can be expensive and can make testing in the schools cumbersome. These hardware prototypes are usually hand-built and available in only limited quantities. Furthermore, when the materials are prepared for publication they may have to be rewritten. These drawbacks, however, are balanced by more sophisticated authoring systems, better color, resolution and sound, and larger memories. Taking advantage of the rapid improvement in the hardware appearing on the market, therefore, will continue to be a major challenge for the courseware designer of the '80s.

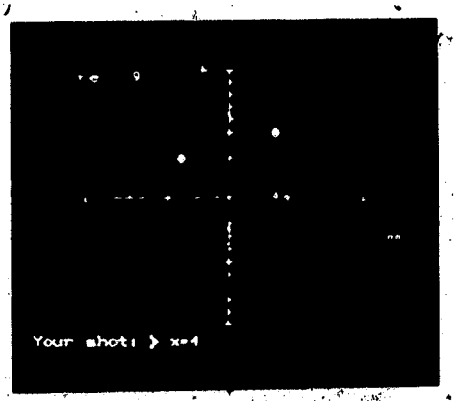
Two projects will be using computer-controlled videodiscs. Isaac Bejar at the Educational Testing Service will be

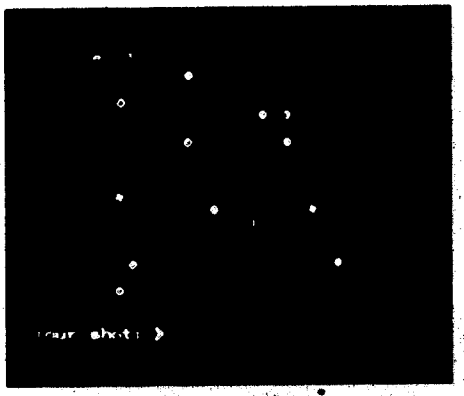
working on elementary mathematics instruction. James Laffey at the University of Washington will endeavor to interest minority students in careers in biology through courseware which explores the use of mathematics in biology.

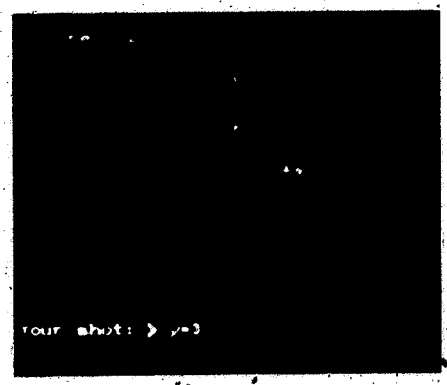
Why not use color? Many projects are using both color and sound. Other than as attention-getting features, very little rationalization is given for why they are useful, but undoubtedly the relatively modest additional hardware investment required is one reason for choosing them. Many of the projects using black and white monitors chose them intentionally because they provide the better resolution which is necessary for accurate graphs and diagrams. Effective uses of color and sound are both areas of opportunity for further research and development activities. Only one of these projects, Wallace Feurzeig's at Bolt, Beranek and Newman, is researching the effective uses of sound in mathematics courseware. Good research on both the motivational and instructional reinforcement qualities of color and sound would be useful in creating more effective courseware. Public support for this research would assure that the findings were in the public domain.

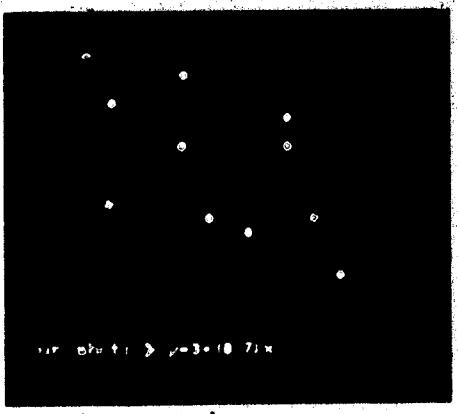
Probably the most compelling use of color thus far is Sharon Dugdale's "Green Globs," an algebra game. The objective of the game is to write equations whose curves touch (and explode) all of the Green Globs. The more Globs touched by an equation, the higher the score.

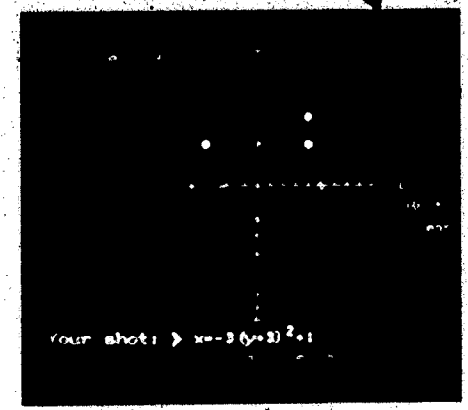
Figure 9. Sharon Dugdale at the University of Illinois at Champaign/Urbana wrote "Green Globs," an algebra game. Write an equation to touch as many Green Globs as you can.











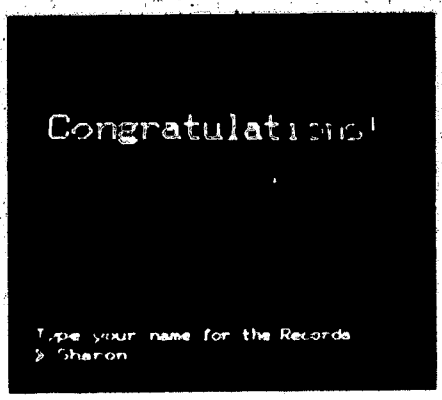


Figure 10. The students' successive equations.

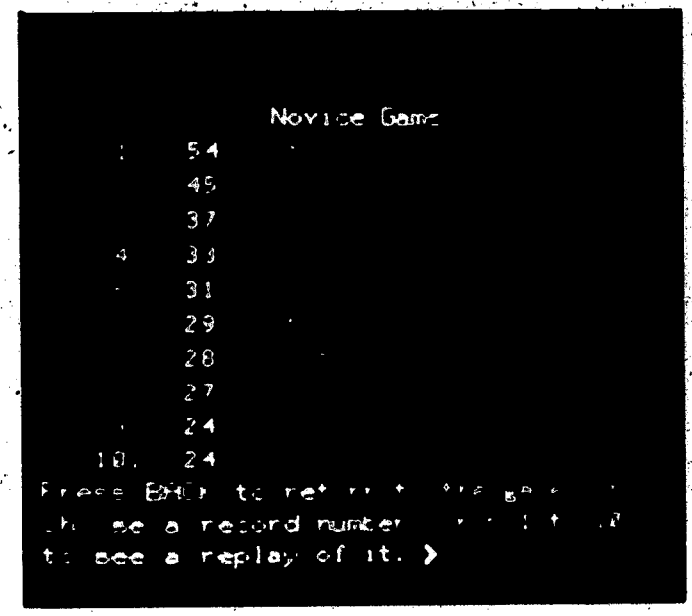


Figure 11. The Hall of Fame records the highest scoring games.

The computer keeps a record of the highest scoring games, called the Hall of Fame, and other students can go back and replay these successful games. The students can learn from each other through this replay strategy as well by working together on games.

What languages were chosen? Approximately half of the projects are using BASIC and half are using PASCAL. Two projects use LOGO. The Program suggested no changes in language choice.

How will the structure of the learning environment change? Some people feel that the first way a computer enters the classroom is as a tool for the teacher. If all materials are completely individualized, it becomes more difficult for schools to use the computer effectively with a small, initial hardware purchase. Very few schools will initially buy computers for each two or three children. Some projects are writing courseware for the computer used as a teacher tool (Figure 12); others create materials for students to use individually or in groups (Figure 13).

The computer-centered classroom is a concept that is appearing more frequently in classrooms. Seymour Papert of M.I.T. described this approach as "the computer as pencil". Just as teachers now working with students in class use pencils and paper and perhaps a hand calculator, in the future each student will have his own computer. The computer is a student tool within a classroom for creating programs or doing algebra problems. This approach will not seem unreasonable when a powerful computer is as inexpensive as a hand calculator is today. A variety of new environments seems promising for our schools in the future.

How much does it cost? These Fiscal Year 1980 and 1981 projects represent a Federal investment of approximately $4,000,000.

In Fiscal Year 1980, a little over $2 million was invested; in Fiscal Year 1981, the number is a little closer to $1.5 million. Figure 15 illustrates that projects are supported at a variety of investment levels. These figures indicate Federal investment; several projects also involve substantial contributions by the grantee institution, by local schools and/or by the private sector.

Figure 12. Gerald Isaacs' project at Carroll College explores the computer as a tool for the teacher of pre-calculus mathematics.

Figure 13. Herman Hughes' students at Michigan State University work both individually and in groups.

The Future

The combined topic of mathematics and computers is one that many people believe is important. Mathematicians and classroom mathematics teachers, not only computer scientists or necessarily even computer specialists, are developing new tools for the classroom. Their enthusiasm is based not upon cost-effectiveness, but upon their ability to create new, compelling tools for teaching mathematics. They are persuaded by the value added to their courses rather than by the dollars saved by their universities and school districts. While costly, computers are not seen to be prohibitively costly. And students, parents and school administrators are agreeing.

Figure 14

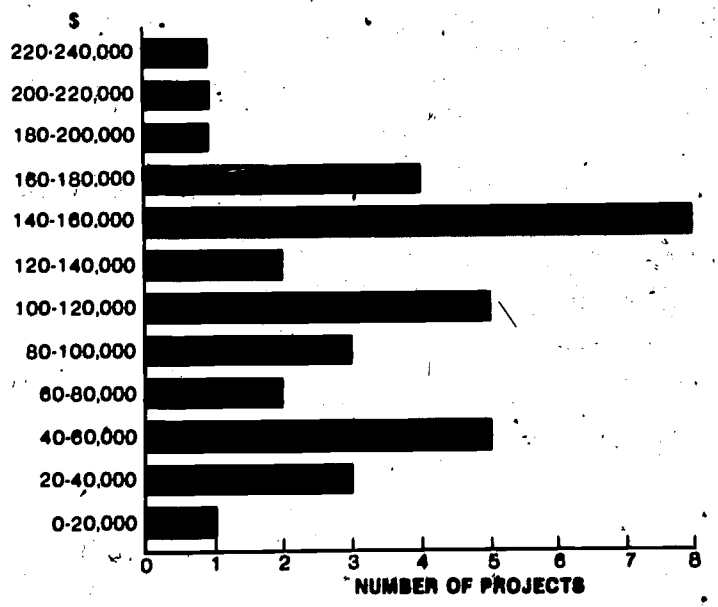
TOTAL FEDERAL DOLLARS INVESTED

PROTOTYPES	No. PROJECTS SUPPORTED	DOLLARS
YEAR 1 (FY 1980)	21	2,278,000
YEAR 2 (FY 1981)	15	1,761,000
		4,039,000
OTHER ACTIVITIES (FY 1981, ONLY)		
NSF/NIE REGIONAL CONFERENCES	4	75,000
		4,114,000*

*This figure includes $505,000 from the National Institute of Education(NIE) invested in NSF/NIE prototype projects and the NSF/NIE Regional Conferences.

Figure 15

FY 1980 AND FY 1981
PROJECTS BY AMOUNT OF FEDERAL INVESTMENT



Although the results are still preliminary, many students who were not interested in mathematics before, are apparently becoming interested and involved because of the visual and dynamic character of the computer, the ability to reveal the mathematical aspects of art and music through the computer, and the computer's ability to provide feedback and interaction for students. Not only is a wider group of students in regular mathematics classes able to have successful experiences in mathematics, but both younger and older students can as well. New strategies and environments are possible for the schools of the 80's and beyond. While innovations always stimulate motivation, project after project reveals heightened motivation for mathematics using computing. This appears to be more than just a Hawthorne effect.

What we have represented here, however, are prototypes of courseware. They are bits and pieces, but nevertheless, building blocks of new mathematics curricula that have not yet been defined in detail. They represent a first, exploratory phase.

Logical next steps include building and testing semester-long prototypes, and eventually K-12 total mathematics curricula. Then, more importantly, this basic set of tools will move to science programs and thereby make mathematics and computing a new basic.

Dorothy K. Deringer
Acting Program Director
Development in Science Education

Acknowledgements

I would like to thank my colleagues at the National Science Foundation Drs. Andrew R. Molnar and Robert F. Watson, and Dr. Barbara Bowen of Queens College, New York, for their advice and assistance in preparing this paper and the slide presentation on which it is based.

I want also to acknowledge the contributions of Dr. Mary Ann Ryan of the DISE staff in handling many of the FY80 and FY81 grants, and of Dr. Edward Esty of the National Institute of Education who worked with me on the NSF/NIE. Improvement of Mathematics Education Using Information Technology effort.

Project Summaries

Advanced Learning Technology
13800 Skyline Boulevard
Woodside, CA 94062

Ann Piestrup

Early Learning (Grades 2-3) of Geometry and Logic, Using Microcomputers

Young children can learn mathematics in a playful, interactive manner using today's microcomputers. Games, inquiry learning sequences, and puzzles can be programmed on a low-cost, powerful computer with color graphics, natural sounding speech, music, and a variety of input devices. Children can use a joystick, a graphics tablet, a light pen, and a special children's keyboard to explore mathematics concepts. The project will develop microcomputer software which will enable children aged 7 and 8 to discover geometry concepts and to develop logical thinking. The microcomputer programs will be paced and sequenced to provide a dynamic learning environment for young children. Some computer programs will be prepared in three versions: with standard English, Black standard English, and Spanish voice prompts. Teacher's manuals for each program will be written in Spanish and English. The programs will be designed for gifted children as prototypes of a mathematics enrichment curriculum on microcomputers. Commercial publication will be sought.

Award Number: SED 80-12510 (NSF/NIE)*
Award Amount: $130,000
Duration: September 10, 1980—February 28, 1982

Dixie School District
Miller Creek School
380 Nova Albion Way
San Rafael, CA 94903

Ronald Saltinski

Middle School Microcomputer Statistics Laboratory

The primary objective of the project is to create an environment in which middle school students will have the opportunity to develop a sense of statistical reasoning as an integral component of problem solving in science and mathematics. A statistics laboratory will be created in which students will receive instruction in statistics and assistance in applying statistical techniques in science, social studies, and other areas of study. The microcomputer will be used as a tool to solve these statistics problems. The project will generate a low-cost model with supporting courseware, competency statements, and guidelines for instruction and evaluation of hardware and software. Commercial publication of the materials produced in the project will be sought.

Award Number: SED 80-24417 (NSF/NIE)
Award Amount: $10,035
Duration: May 15, 1981—April 30, 1983

University of California, Berkeley
Lawrence Hall of Science
Berkeley, CA 94720

John David Miller

Elementary Mathematics Concepts with Calculators: Microcomputer-Based Modules for Teachers, Parents, and the Public

This project will develop a pilot, three-hour instructional program for using calculators in elementary mathematics teaching. The audience for this instruction will be 4th, 5th, and 6th grade teachers; support personnel; parents; and members of the public. The delivery system for this instruction will consist of three highly interactive microcomputer-based programs. The programs will enable teachers to begin using many kinds of calculators together with any regular math text. A subset of this instruction will be for parents and the general public—to explain to them the use of calculators in mathematics teaching and to enlist support for the teachers. For over four years, professional mathematics educators have urged the use of calculators in mathematics education. Presently, 90% of elementary classrooms do not use calculators to any significant degree.

Award Number: SED 79-19000 (DISE)
Award Amount: $98,027
Duration: May 15, 1980—April 30, 1982

*Some projects received partial funding from the Research in Science Education (RISE) Program because of a research element in the project. Such projects will be marked "RISE/DISE." Some projects received funding from the National Science Foundation/National Institute of Education Improvement of Mathematics Education Using Information Technology Program. Those projects will be marked "NSF/NIE." Projects funded totally by DISE will be so designated.

University of California, Santa Barbara
Santa Barbara, CA 93106

Marvin Marcus

Intensive Computer-Based Mathematics Training for Re-entry Women

This project will develop a computer-based mathematics curriculum for women who wish to upgrade skills needed for continuing education or re-entering the technical job market. The project will design and implement a graded sequence of instructional units—covering such topics as real and complex numbers, functions, linear systems and probability—for two intensive summer short courses and subsequent home-study/microcomputer laboratory phases, using low-cost, stand alone, commercially available microcomputers located on the Santa Barbara campus.

One hundred women between the ages of 25 and 55 will be selected for the program, taking into account commitment, career goals, demographic mix, and need. Participants will be randomly assigned to control and treatment groups. Only those in the treatment group will receive the intensive mathematical training, but both groups will be tested regularly throughout the length of the program to determine the effectiveness of the intervention.

The project will develop and disseminate (1) written instructional units covering the pertinent mathematics and microcomputer-based "discovery" exercises; (2) intelligible manuals for learning a computer language and simple machine operating techniques; (3) a "how-to" manual on setting up an inexpensive microcomputer laboratory to work effectively with non-traditional students' own video tapes of the lectures; and (5) a newsletter, published every three months to disseminate project's results. The materials and course designs will be made suitable for easy transfer to other institutions.

Award Number: SED 80-20411 (DISE)
Award Amount: $192,012
Duration: March 1, 1981—October 31, 1983

University of California, Santa Cruz
1156 High Street
Santa Cruz, CA 95064

Kristina Hooper

Visual Geometry and Mathematics Cognition for Beginning College Science Students

This project will develop prototype materials for a pre-calculus-level course in visual geometry at the introductory level. Using computers with interactive graphics, the materials will train students in visualizing patterns and then transforming them to symbolic forms, a mastery vital to the concept of mathematics which is often lacking in re-entry, women, or minority students. This lack may contribute to difficulty in gaining access to scientific or technological careers.

As preparation for materials development, the project will perform the following: (1) analyze the current difficulties and attitudes of students interested in science careers but without the normal self-confidence and preparation; (2) develop techniques for evaluating and improving skills in spatial visualization and visual-verbal translations; (3) collect and characterize the impact on students of current materials in visual problem-solving and geometry; (4) assay the introductory science curriculum of UCSC for the demands placed on math understanding; and (5) develop specifications for computer equipment needed for interactive visual instruction. Expected outcomes include documented techniques for a "new generation" of learning materials, example materials, and insights into the role of visual modes of representation in math cognition and in overcoming problems some students have in beginning science college courses.

Award Number: SED 79-19778 (DISE)
Award Amount: $235,174
Duration: June 13, 1980—December 31, 1982

University of California, Santa Cruz
Santa Cruz, CA 95064

Edward M. Landesman

Microcomputer and Video-Based Mathematics Modules for High School Women and Minority Students

This project will develop six learning modules which will make use of a combination of media (microcomputers, videotape, and printed workbooks) to assist minority and women students in learning high school mathematics. The proposed approach is based on social learning theory, which synthesizes cognitive and behavioral perspectives. The modules will be designed to aid learners in mastering key concepts, strengthening needed skills, and reducing feelings of learned helplessness or anxiety in mathematics so that the necessary preparation may be acquired to pursue post-secondary studies in science and technical fields.

Interactive computing will be combined with video sequences and printed workbooks to provide the learner with a powerful mix of learning activities based on task analyses and learning objectives. This combination of media is particularly useful in relating mathematical concepts to their applications, demonstrating the importance of mathematics in life and careers, and providing self-paced, interactive rehearsals in generalizing concepts and mastering skills. The proposed work will use equipment that is already available in many high schools, and will provide a foundation for future uses of intelligent videodisc technology.

The project team includes senior academic and professional staff having expertise in mathematics, educational

psychology, graphic arts, and computer-assisted instructional techniques. The team also includes high school teachers of mathematics.

Award Number: SED 80-24701 (DISE)
Award Amount: $176,444
Duration: April 1, 1981—March 31, 1983

San Francisco State University
1640 Holloway Avenue
San Francisco, CA 94132

Jose E. Gutierrez

Mathematics Network Curriculum Project for Middle School Teachers and Students

This project, for the introduction of microcomputers into the middle school mathematics curriculum, has three objectives: the development of seven curriculum prototypes (units), a model for the teachers, and the development/implementation of a computer communications system (network) to bring together the separate classrooms. The computer activities will stem from classroom activities that utilize the manipulation of real objects and/or the activities of the students themselves. Each unit incorporates five elements: games; simulations; classroom activities; data storage, retrieval and processing; and interclassroom interaction. Dynamic software will be developed to provide both structure and freedom for student manipulation of data and interaction with the mathematical content and concepts. The network will provide for interaction of students and classrooms with each other, teachers with each other, and all of these with the university data base. The interaction will enhance participation and motivation of both students and teachers. The project will disseminate information at professional meetings and will explore the possibilities of commercial publication of the materials.

Award Number: SED 80-12465 (NSF/NIE)
Award Amount: $130,811
Duration: September 17, 1980—February 28, 1983

University of Colorado
School of Education
Boulder, CO 80309

Marc Swadener

Personal Computers and Cross-Age Instruction

This project will develop an instructional strategy combining use of personal computers and cross-age instruction. The development plan includes identifying 60 low-achieving sixth grade students and 60 non-math/science oriented, able tenth grade students. (Half of each group will be randomly assigned to experimental control groups.) During the first semester of a two semester program, 30 tenth graders will study specific areas of math weakness of 30 sixth graders and will develop microcomputer courseware for them. Each tenth grader will tutor one sixth grader during the second semester, using and further developing courseware. The anticipated results of the project include an improvement in math and problem solving skills of both groups of students and increased enrollment in math and science classes beyond grade 10. The project will produce a tested instructional strategy, a curriculum for high school students and computer software.

Award Number: SED 79-18974 (DISE)
Award Amount: $84,917
Duration: September 15, 1980—February 28, 1983

University of Florida
College of Education
360 Norman Hall
Gainesville, FL 32611

Mary Grace Kantowski

Instruction for Problem Solving Using the Microcomputer in High School Mathematics

This project will develop prototypes of instructional materials for nonroutine and real problem solving to be used with a microcomputer. The effectiveness of these materials in promoting growth in the problem-solving ability of students in grades 5 through 12 will be studied. Prototypes will be developed in two areas of mathematical problem solving (geometry and number theory) as well as in real problem solving so that multiple aspects of the potential of the microcomputer can be exploited. The graphic capabilities may be used to great advantage in the geometry problems, and the iterative and calculator capabilities are most useful in number theoretic problems. Interaction with the computer will be emphasized.

The comprehensive series will include introductory videotapes (or intelligent discs) and software packages in problem-solving techniques. Supplementary printed materials will be available in some cases. An important aspect of the final product will be a collection of sequences of similar problems. Hints or cues will be provided for a number of possible solution paths. In addition, each set of problems will include supplementary instruction in key content areas as well as useful algorithms. Materials will be submitted to consultants for critical evaluation. Programs will be demonstrated in NCTM meetings at St. Louis in 1981 and Toronto in 1982. Progress reports and materials will be distributed to those interested in mathematics education.

Award Number: SED 80-12466 (DISE)
Award Amount: $110,322
Duration: August 1, 1980—October 31, 1982

Georgia Institute of Technology
225 North Avenue
Atlanta, GA 30332

Les A. Karlovitz

Microcomputer-Based Strategies for Mathematics in Junior High and High School

This project will develop computer programs called IDP's (interactive demonstration programs) for use on microcomputers capable of generating high resolution video graphics to treat key topics in traditional junior high and high school mathematics courses—primarily general mathematics, algebra, geometry, and calculus. The programs will apply the technology to the tasks of computation, graphical display, and simulation in order to clarify and explain the subject matter. The classroom component of the project is complemented by a laboratory component in which students experiment individually with the programs and carry on related activities.

The primary product of the project will be the demonstration of a teaching model which makes use of computer programs for classroom demonstration and laboratory use in mathematics courses. The programs themselves, which will be available when the project is completed, will be designed to bring ideas and numbers together more effectively for the understanding of mathematical concepts and procedures, promote classroom participation by virtue of the interactive nature of the programs, provide multiple viewpoints and contexts for the treatment of the given topic, and allow for a useful redistribution of the teachers' time. Teachers from the Atlanta public school system will be actively involved in the planning and development of the IDP's to ensure their quality and effectiveness. A distribution network for the materials will be provided by the Southwestern Consortium for Minorities in Engineering. The project is designed for future expansion to other courses and grades and to a large geographical area.

Award Number: SED 80-12649 (NSF/NIE)
Award Amount: $88,800
Duration: August 1, 1980—October 31, 1982

Illinois State University
344 DeGarmo Hall
Normal, Illinois 61761

Gary W. Tubb

Females' Acquisition of 8th Grade Geometry Concepts via Non-Verbal Microcomputer Graphics

This project is designed to: (1) improve the acquisition of geometry concepts of 8th grade females; (2) produce software in a working model format that clearly illustrates the utility of microcomputers in geometry and is easily modifiable by educators; and (3) produce a non-verbal symbol-based geometry model using microcomputer graphics. The project is based on research that indicates that females develop spatial abilities differently from, as well as later than, males.

This project will result in: (1) 19 nonverbal, 15-minute interactive instructional modules for a microcomputer which demonstrate at the 8th grade level translation, reflection, rotation, congruence, symmetry, invariance, triangles (SSS, ASA, SAS, AAS), sum of angles, corresponding and alternate angles; (2) identifying the stages of spatial acquisition of the above geometry concepts by sex by age; and (3) determining the adequacy of a graphics pad in the acquisition of geometry concepts via microcomputer. This project has attracted the interest of a computer vendor who will support the equipment. The modules will be discussed at national meetings and will be offered for commercial publication.

Award Number: SED 80-24507 (DISE)
Award Amount: $55,500
Duration: September 15, 1981—February 29, 1984

University of Illinois
Urbana, IL 61801

Sharon Dugdale

Prototype Microcomputer Courseware for Teaching High School Algebra

This project will develop microcomputer courseware to teach basic algebra concepts to secondary students (grades 9-12). Materials will be developed to teach recognition of general functional relationships and graphing of linear and quadratic equations. The materials will use an "intrinsic models" approach. This approach uses motivating activities which are direct expressions of the underlying mathematics such as games based on the mathematical principles involved. The materials will be designed for and tested on a color graphics microprocessor-based system which uses a standard color television set, and a floppy disk for program storage. This hardware has capabilities which can be expected to be widely available in a few years' time.

Award Number: SED 80-12449 (DISE)
Award Amount: $111,300
Duration: July 15, 1980—June 30, 1982

Ball State University
Department of Mathematical Sciences
2000 University Avenue
Muncie, IN 47306

Bernadette H. Perham

Microcomputer Applications of Mathematics in High School Management Science

This project will develop high school level microcomputer-based curriculum materials for teaching the mathematics

that is used for decision making in the management sciences. The products will be five independent modules on the topics of matrix theory, game theory, linear programming, network theory, and Markov chains. The modules will contain computer programs to be used in problem solving, student and instructor manuals, a book of problem sets based on the mathematics used in decision theory, and tests for evaluating student achievement. The modular nature of the materials will make them suitable for incorporation into existing high school mathematics courses, for collective use as a one-semester course on decision theory, or for use in independent study projects.

The development of these materials addresses the need expressed by mathematics educators for high school courses which stress problem-solving strategies, applications, and the skilled use of computer technology. The increasing availability of microcomputers in the high school makes possible the presentation of mathematical problems arising from real business world situations for which solution by conventional means would involve tedious computations.

Award Number: SED 80-24418 (DISE)
Award Amount: $79,482
Duration: August 1, 1981—July 31, 1983

University of Maryland, College Park
College Park, MD 20742

James T. Fey

Microelectronic Technology: Implications for Secondary School Mathematics Curricula

The central concern of this project is how best to employ microelectronic technology in science and mathematics curricula in high schools. Such existing and projected technology permits machine performance of nearly all formal manipulations that students now learn in high school mathematics. However, to date, school curricula have undergone almost no broad change to reflect the emergence of powerful computer-based work environments in science and mathematics.

This project will address three basic questions:

1. What is the best possible mathematical software projected to be available for use in doing high school level mathematics by 1990? A prototype of this environment will be designed and implemented to the extent permitted by the evolving state-of-the-art.

2. What mathematical skills and understanding will students need in order to use the new computing power effectively? An elementary calculus course and introduction to mathematics course will be revised and taught using the prototype mentioned above.

3. How might appropriate change in school mathematics be initiated, given the complex interrelation of curriculum expectations by students, parents, teachers and college faculty? An invited conference will be held to explore this question with leaders in the field. Recommendations and proceedings will be published and disseminated.

Award Number: SED 80-24425 (DISE)
Award Amount: $203,558
Duration: June 15, 1981—May 31, 1983

Bolt, Beranek and Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Wallace Feurzeig

Development of an Articulate Instructional System for Teaching Elementary School Arithmetic Procedures

A computer-based instructional system with advanced capabilities for teaching arithmetic algorithms and elementary mathematical procedures will be developed. Whole number computation will be emphasized and synthesized speech will be used extensively with visual displays. In demonstration mode, the system explains the detailed execution of a procedure to the student as it shows its work on a display. In guided practice mode, the student works through a procedure and the system diagnoses his work. The system is articulate and diagnostic. Its explanations and error evaluations use computer-generated speech. The prototype design will be tested and evaluated using a variety of instructional strategies and content materials. Although the extensions over conventional tutorial CAI methods are technically straightforward, their qualitative improvements are pedagogically of the highest importance because of the union of synthesized speech and advanced cognitive models of learning.

Award Number: SED 80-12481 (SEDR/Special Activity)
Award Amount: $160,343
Duration: August 1, 1981—April 30, 1983

Education Development Center, Inc.
55 Chapel Street
Newton, MA 02160

Judah L. Schwartz

Application of Dimensional Analysis to Middle School Mathematics Using Microcomputer and Print Materials

This project will develop a collection of tested mathematical word problems which will be available both in printed form with graphics and in the form of interactive computer programs for use with a microcomputer. The problems will be set in contexts that are interesting to junior high school students. The approach to problem solving will be based on the technique of dimensional (semantic) anal-

ysis commonly used in university-level physics and engineering. A core group of six to ten teachers in the Boston area will collaborate closely with project staff in the development of materials and will test materials initially. A larger group of 50 teachers with access to microcomputers in several urban areas around the country will then receive all materials and have complete discretion as to their use. Evaluation will be based on the extent to which these teachers voluntarily use the materials provided, and the responses of the teachers and their students after using them. The project will also produce a report presenting insights gained on the following issues in the course of developing and testing the materials: (1) the generation of a computer-based curriculum in mathematics and other subjects; (2) the interaction of printed and computer-based materials; (3) computer-generated printed materials custom tailored to particular student interests; (4) the attitudes of teachers toward the present and future roles of computers in education; and (5) the training of teachers to use computers for their own ends, both as professional teachers and as functioning adults in society.

Award Number: SED 80-12611 (DISE)
Award Amount: $156,101
Duration: September 1, 1980—September 30, 1982

Waterford School District
6020 Pontiac Lake Road
Waterford, MI 48095

Randy E. Gross

Using Problem Solving in Junior High Mathematics

This project uses microcomputers for teaching problem-solving skills in mathematics in grades 7-9. Materials will be developed by experienced teachers who have developed computer software and use microcomputers in their classrooms. The project objectives include developing instructional packages for junior high mathematics, including simulations; inquiry activities; educational games; and programming materials.

The goal of the project is to develop materials which improve students' ability to solve real-life problems, use induction, work with algorithms, and think abstractly.

Commercial publication will be sought for materials produced by this project.

Award Number: SED 80-24463 (NSF/NIE)
Award Amount: $71,051
Duration: June 15, 1981—May 31, 1983

Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, MA 02139

Seymour Papert

Interest World: Pre-College Mathematics in a Computer Culture

This project will develop an alternative to the traditional uniform mathematics curriculum. The new model of education will be computer-based "interest worlds." These interest worlds will serve as significant routes into the achievement of "computer literacy" on a broad scale. The key idea behind the project is: If people have developed a serious interest and significant expertise in some activity and its associated body of knowledge, then it should be possible to design computer systems that help them pursue that activity, and at the same time draw on their expertise and emotional attachment to support mathematics learning. Four interest worlds will be developed: Words World, Games World, Music World, and Animation World. The interest worlds will be tested in a 6-week summer program for 24 mid-elementary to junior high school youngsters.

Award Number: SED 80-12648 (NSF/NIE)
Award Amount: $165,434
Duration: September 1, 1980—July 31, 1982

Wayne State University
College of Education
223 Education
Detroit, MI 48202

John S. Camp

Computer-Enhanced Statistics Modules for the Upper Elementary Grades

This project will develop prototype computer-enhanced elementary mathematics curriculum units. It will use computers for simulation, games, information storage and retrieval, and open and guided discovery to introduce upper elementary school students to statistics. A major focus will be the development of students' heuristic problem-solving skills through their command of the computer's capability to simulate experiments, alter values of variables, make tables, draw graphs, present a simpler problem, or present a related problem. The units will include goals, objectives, computer and/or non-computer learning experiences, teacher guides, and evaluation instruments.

Formative and summative evaluations will be conducted to assess the materials, their usefulness, and student outcomes. The project will also produce a teacher education module for future teachers of the statistics materials.

Award Number: SED 80-24223 (NSF/NIE)
Award Amount: $110,442
Duration: June 1, 1981—May 31, 1983

St. Olaf College
Northfield, MN 55057

Lynn Arthur Steen

Microcomputer Instructional Units (for 11th and 12th Grade Mathematics) Using Simulation of Mathematical Modeling

Three prototype instructional units will be developed for microcomputers, each using simulation of mathematical modeling as a vehicle with which students can explore the geometrical and physical bases of mathematical relationships. The simulation programs will employ color graphics (with a graphic input pad) to illustrate physical and geometrical processes. Students will use the programs as experiments, trying different parameters and conditions, in order to collect data and formulate conjectures. The program packages will permit students to test their conjectures for consistency with the simulations, and will suggest exploration of possible sources of error. The materials will be tested in high school, college, and in adult continuing education classes. Each program package will be a self-contained instructional unit on some topic illustrating mathematics ordinarily encountered in grades 11 and 12. Each will be accompanied by a supplementary pamphlet suggesting problems, projects, and further reading.

Award Number: SED 80-12463 (NSF/NIE)
Award Amount: $54,984
Duration: July 1, 1980—June 30, 1983

Educational Testing Service
Princeton, NJ 08541

Isaac I. Bejar

Interactive Videodisc Applications to Elementary Mathematics Education

This project will design an interactive (computer-controlled) videodisc system for use in teaching the elementary mathematics topics of decimals and fractions. This system will incorporate in a single delivery system the advantages of several instructional techniques: one-way television, computer-assisted instruction, sophisticated measurement designs, analysis of student errors, and detailed record keeping.

The system is viewed as a viable mechanism for progress toward equal educational opportunity in a cost-effective manner. The initial effort will concentrate on a self-contained mini-curriculum combining fractions and decimals. Materials will be tested in fourth and fifth grade classrooms. At the conclusion of the project the production handbook, the videodisc, the software for the lessons and the final report will be disseminated.

Award Number: SED 80-24465 (DISE)
Award Amount: $147,918
Duration: May 15, 1981—April 30, 1983

All Indian Pueblo Council
1015 Indian School Road
Albuquerque, NM 87197

Judith A. Hakes

Computer Storytelling Mathematics for Pueblo Indian Upper-Elementary Level Students

This project will develop an alternative, computer-based learning unit in mathematics and science for upper-elementary level Pueblo Indian students. The project will produce and field test a four- to six-week unit entitled "Pueblo Uses of Energy" which fuses mathematical problem solving with science content related to the daily lives of the Pueblo students. The major role of instruction will be the microcomputer interfaced with a tape recorder. Instructional programs will be designed to introduce content and skills in a storytelling format which capitalizes on a specific learning style of Pueblo culture. The project will be accomplished in two 6-month phases; 1) design and 2) field development, revision and dissemination. The computer programs, audio tapes, and printed materials developed will be disseminated through the Education Division of the All Indian Pueblo Council to Bureau of Indian Affairs schools and other educational programs. Materials will also be available at the American Indian Bilingual Education Center at the University of New Mexico. Results of the project will be presented in journal publications.

Award Number SED 80-12482 (NSF/NIE)
Award Amount: $59,444
Duration: September 19, 1980—February 28, 1982

Educational Solutions, Inc.
80 Fifth Avenue
New York, NY 10011

Caleb Gattegno

Microcomputer Courseware to Develop Insight into Arithmetic Using Perceivable Algorithms

The project presents a new way of using microcomputers for teaching mathematics. The prototype will be field tested with first and second graders and early adolescents (middle school age) in predominantly minority public schools in New York City. The ultimate target audience will be elementary and middle school students. The approach to be used is based on learning through insight rather than drill. The computer is used to generate insight in students by interacting with them in such a way that their attention is focused on mathematical relationships and transformations. Prototype courseware for generating insight and skill in numeration, addition, and subtraction will be produced, field tested, and refined.

Award Number: SED 80-12612 (DISE)
Award Amount: $52,000
Duration: September 15, 180—July 31, 1982

Rensselaer Polytechnic Institute
Mathematical Sciences Department
Troy, NY 12181

Edith H. Luchins

Improving Spatial Skills in Pre-College Mathematics Through Computer Graphics

This project will develop and test experimental educational materials intended to improve mathematical problem solving by training in spatial visualization and orientation. Spatial skills have been shown to be good predictors of mathematical performance and grades in mathematics courses and to be important in certain occupations. Among modern technologies, computer graphics has special potential as a tool in spatial visualization and orientation training. This project will develop and produce software (which will be available at the end of the project) to generate a variety of instructional courseware. Students will interact with subject matter using individual computer graphics systems. The computer programs will evaluate student responses and adapt the training sequence. Moreover, this software will enable teachers to design new training experiences without special knowledge of computing. Testing of materials will be done at a public and a private high school. Pre- and post-training testing of spatial and mathematical abilities will be administered to experimental and control subjects. Since sex differences in spatial abilities have been reported widely, the project will compare the changes in spatial skills shown by males and females.

This project includes a Small College Faculty Research Supplement to enable Dr. Ruth Murray, Chair of the Mathematics Department of Russell Sage College, to continue her research in the learning of mathematical spatial concepts and in math anxiety and avoidance in women.

Award Number: SED 80-12633 (NSF/NIE)
Award Amount: $133,817
Duration: August 15, 1980—July 31, 1982

State University of New York/Stony Brook
Department of Technology and Society
Stony Brook, NY 11794

Ludwig Braun

Development of Computer-Based Learning Models in Secondary School Science and Mathematics

This project responds to a national need for quality science and mathematics courseware (computer-based learning units) brought on by the rapidly growing use of microcomputers in secondary schools. Twenty such exemplars covering mathematics, biology, chemistry, and earth/space science will be developed to demonstrate both the structure and content of high quality and effective instructional courseware. Models which enable pre-college level teachers who have very limited computer programming expertise to produce computer-based learning units for their own classes will be created, tested and disseminated. Also to be developed will be: (1) a teacher's guide to assist in modifying exemplars to suit a variety of curricular objectives, and (2) a handbook describing techniques of courseware design along with helpful hints for conversion from one computer to another.

The materials will be tested and evaluated by a large number of teachers and an external advisory/review board comprised of experienced professionals. Dissemination will be carried out through the publication of a newsletter; presentation at national, regional, and local professional meetings; and perhaps later through a commercial publisher.

Award Number: SED 80-25176 (DISE)
Award Amount: $176,225
Duration: July 15, 1981—July 31, 1983

North Carolina School of Science and Mathematics
1912 West Club Boulevard
Durham, NC 27705

Carl Stephen Davis

Coordinated Use of Microcomputers in High School Chemistry, Physics, Biology, and Mathematics

This project seeks to improve the teaching of high school mathematics by developing prototype microcomputer-based materials which show the application of mathematics to chemistry, physics, and biology, and which enhance the teaching of selected mathematics concepts through the use of computer graphics. Students will use microcomputers to apply, in the science laboratory, principles learned in the mathematics classroom. The specific materials to be developed are: (1) software for a graphics package to be used in mathematics classes and science laboratories; (2) nine packages of experiments (three each in chemistry, physics, and biology), consisting of software and courseware (i.e., documentation, workbooks) which permit use of the microcomputer to process experimental data using graphics; (3) a mathematics package consisting of software and courseware dealing with topics in the high school mathematics curriculum for which graphics treatment is particularly appropriate. Students will be able to use these materials without any previous computer experience.

The graphics package will consist of a family of interactive programs basic to the other materials. It will be able to plot experimental data points, plot curves from user supplied equations, calculate numerical approximations to experimental data, and display the calculated curve, data points, and possibly another theoretical curve, all on the same screen. The early portion of the mathematics package

will treat the topics of the graphing of experimental data, the types of experimental errors, and the numerical approximations to experimental data. In the science laboratory the microcomputer will be able to receive experimental data via a graphics tablet or A/D converters, and to process the data using the graphics package in the manner discussed in the math classroom.

Award Number: SED 80-24473 (NSF/NIE)
Award Amount: $78,857
Duration: April 15, 1981—February 28, 1983

Wittenberg University
Springfield, OH 45501

William H. Kraus

The Use of Microcomputers for Mathematics Instruction in Grades 1-4

This project will develop 10 to 15 computer games to be used as supplements to mathematics instruction in grades 1 through 4. The computer will be used as a learning center in the classroom. The games to be developed are based on typical game strategies used with older students: practice in skills; applications of mathematics; and problem solving. Games will be designed for use by both small and large groups. The mathematical content of the programs will cover the 10 basic skills areas identified by the National Council of Supervisors of Mathematics. Development will stress the following: (a) appropriateness of mathematical content; (b) ease of program use; and (c) use of color graphics and animation for increased motivation, user-involvement, and effectiveness of communication. Elementary teachers will be involved in the development of the programs, and the programs will be field-tested in public schools.

Award Number: SED 80-12268 (NSF/NIE)
Award Amount: $25,048
Duration: July 1, 1980—December 31, 1982

Drexel University
Philadelphia, PA 19104

John H. Staib

Computer Graphics in a High School Mathematics Laboratory

This project will develop a series of microcomputer-based mathematics experiments designed to accompany a high school course in elementary mathematical functions. The experiments will constitute a laboratory course which will make use of interactive computer graphics as a means for developing mathematical insights and for otherwise motivating and enhancing the learning of mathematics. These experiments will be designed to encourage the use of inductive reasoning processes.

A team of mathematicians, mathematics educators, and computer scientists will design, develop, and field test the laboratory course. The team will produce the necessary software, a student laboratory manual with worksheets, and a teacher's guide. The project will be a cooperative one including the school district of Philadelphia. The school district will contribute personnel and make possible a classroom test of the materials.

Results of the project will be presented at local and national professional meetings. The materials will be demonstrated at in-service courses for teachers in the Philadelphia area and will be made available to other school systems and individual teachers throughout the country.

Award Number: SED 80-12532 (DISE)
Award Amount: $123,000
Duration: September 30, 1982

Swarthmore College
Swarthmore, PA 19081

Eugene A. Klotz

A Computer Graphics Learning Environment for High School Trigonometry

This project will create a learning environment for high school trigonometry based on microcomputer color graphics units. Students can explore these units on their own or under the direction of a teacher.

These user-oriented materials will be written so that they are highly visual in character, and they will encourage browsing among the lessons rather than requiring the student to adhere to a predefined path.

The primary audience of the materials is the high school academic mainstream. High school teachers are part of the development team and the materials will be tested in two local high schools. A special effort will be made to assure that the materials are attractive to women students.

The product of the effort will be a number of interactive color graphics units, documented and tested, which can be used in learning trigonometry. For wide distribution to potential users, these materials will be submitted to CONDUIT and MicroSIFT (a clearinghouse for pre-college computer-based materials supported by the National Institute of Education).

Award Number: SED 80-24474 (NSF/NIE)
Award Amount: $149,799
Duration: May 15, 1981—April 30, 1983

University of Pittsburgh
1028 Cathedral of Learning
Pittsburgh, PA 15261

Lauren B. Resnick

Semantics of Arithmetic: Teaching Understanding and Computational Skill via Computer

This project will use small computers to provide basic instruction in arithmetic. The instruction will connect performance of the computational algorithms to understanding of the underlying mathematical principles. The instructional program will be based on principles derived from empirical study and theoretical analysis of an important part of elementary school mathematics, i.e., arithmetic procedures that depend upon a knowledge of place value. The program builds understanding of these procedures by helping the child develop detailed correspondence between two systems for representing numbers (using blocks as well as written notation) and arithmetic operations in those systems. The program will provide practical instruction, usable in classrooms at reasonable cost, as well as an opportunity to test the validity of a developing theory of the origin of arithmetic errors and ways of preventing these errors through meaningful instructions.

Award Number: SED 80-12511 (RISE/DISE)
Award Amount: $152,256
Duration: September 1, 1980—August 31, 1982

Christian Brothers College
650 E. Parkway South
Memphis, TN 38104

Joel Baumeyer

Using a Visual Technique to Teach High School Students the Concept of Variables in Polynomials

This project will assist students who have difficulty in the manipulation of the basic symbols used in introductory algebra. This difficulty leads to a failure to understand the true nature of a polynomial and precludes the further study of mathematics. Four objectives are to be attained: (1) the student will learn to use "polyboxes" in order to understand the concept of a variable polynomial (the "polybox" is a visual device that replaces the variable "x" in a way that is visually more obvious than standard notation); (2) software for computer programs will be written to use "polyboxes" with a visual display on an interactive display terminal which includes feedback from a small computer; (3) students will use the software in lessons devised as a module for classroom instruction or self-paced instruction to learn the manipulation of basic polynomials and to obtain a better understanding of the nature of a polynomial; and (4) the module, consisting of five lesson plans including the typical teacher aids of performance objectives and tests and written in a programmed learning self-paced mode, will be prepared and packaged. This project is geared to the 11th and 12th grade student taking algebra and/or junior college student or college freshman taking introductory college algebra. The evaluation and dissemination will take place in a pilot classroom with students and in a workshop with secondary school teachers of algebra. Teachers will evaluate this project relative to the usefulness of the module in their individual classrooms.

Award Number: SED 80-12518 (DISE)
Award Amount: $34,106
Duration: September 1, 1980—February 28, 1983

WICAT, Inc.
Learning Design Laboratories
1160 South State, Suite 10
Orem, UT 84057

C. Victor Bunderson

Mental Errors in Arithmetic Skills: Their Diagnosis and Remediation in Pre-College Students

This project will study methods of diagnosing consistent mental errors (termed cognitive bugs) exhibited by students in elementary arithmetic, the frequency and stability of such errors, and ways to remedy the errors using a microcomputer. Three populations will be involved in the study: third to fifth graders in Orem, Utah; fourth to sixth graders in Salt Lake City (including students from the middle class, urban poor, and minority groups); and teenaged juvenile delinquents in Salt Lake City alternative schools. The objectives are the following: (1) to develop cognitive diagnostic models and tests in subtraction, multiplication, and addition of fractions; (2) to obtain data to determine the need for computerized diagnostic testing for each of the three areas; (3) to develop, if the cognitive bugs are frequent enough and stable, microcomputer-based diagnostic tests to follow paper and pencil screening tests; (4) to develop microcomputer-based remediation programs to structure a remedial interchange between a student and tutor.

The diagnostic and remedial programs will be evaluated in field experiments. The materials will be made available to interested parties upon request. Research findings will be disseminated via presentation at national conferences and publication in professional journals.

Award Number: SED 80-12500 (RISE/DISE)
Award Amount: $141,544
Duration: September 15, 1980—August 31, 1982

Virginia Commonwealth University
901 West Franklin Street
Richmond, VA 23284

J. Richard Morris

Graphing in High School Level Algebra and Trigonometry for Adults

A software package of 15 to 20 graphing lessons intended for use on a computer graphics terminal will be developed by three members of the Mathematical Sciences Department at Virginia Commonwealth University. This package will be used by students on an individual and personalized basis with the help of a qualified teaching assistant. The software will augment existing courses in elementary algebra, intermediate algebra and trigonometry. The content of these courses is the same as that found at grade levels 10 through 12. Each lesson in the software package will be written so that the student is an active participant in the graphing process.

Appropriate testing will take place at each stage of development to insure the effectiveness of the graphing lessons. When the software is complete, a control group and an experimental group will be selected from among the groups of students of age 25 and over. Both student achievement and attitude will be assessed. Guidelines established by CONDUIT will be used as a basis of project organization and management. The software and the new knowledge which result from the project will be disseminated.

Award Number: SED 80-12447 (NSF/NIE)
Award Amount: $55,494
Duration: July 1, 1980—December 31, 1982

University of Washington
Educational Assessment Center
4535 Schmitz Hall PB-30
Seattle WA 98105

James M. Laffey

Mathematics in Biology: Computer-Controlled Videodisc Materials for Women and Minorities (High School and Undergraduate Level)

This project will teach mathematics within the context of biology to women and minority students who are interested in careers in the life and health sciences. The project will use an intelligent (computer-controlled) videodisc system and the material will be suitable for use in high school, community college or university environments. Four modules will be developed on the topics of proportional reasoning, measurement and notation, functions and their representation, and sampling. The results will be reported in the appropriate journals. Presentations will be made at national meetings and the videodisc will be available, on a cost-recovery basis, from the Univesity of Washington.

Award Number: SED 80-24346 (DISE)
Award Amount: $117,400
Duration: July 15, 1981—December 31, 1983

Carroll College
100 N. East Avenue
Waukesha, WI 53186

Gerald L. Isaacs

Geometric Visualization: Dynamic Graphics to Develop Mathematical Perception and Intuition in Pre-Calculus Students

This project is a joint effort between Carroll College and the Waukesha Public School System. Its primary purpose is to improve the teaching of pre-calculus courses through the introduction of geometric visualization techniques using the graphics capabilities of low-cost microcomputers and television displays. The approach will be to promote understanding, using geometric representation and interpretation. An equally important goal is to introduce a prototype for designing graphics software to be used throughout mathematics and science education. This software will be designed in such a way as to be easily transported across hardware, graphics devices, and dialects of BASIC. The project revolves around the concept that there are many topics in mathematics that can be better, presented and understood with the aid of dynamic graphics. To insure widest possible use, the software will be designed so that the instructor need only turn on the machine and start the program. The package would then present the material in English with appropriate prompts and a clear indication of the options available at each step. The project will be discussed at national meetings, papers will be submitted to professional journals, and the courseware and documentation will be disseminated initially through Carroll College and CONDUIT.

Award Number: SED 80-12457 (DISE)
Award Amount: $149,327
Duration: September 15, 1980—August 31, 1982

Racine Unified School District
2220 Northwestern Avenue
Racine, WI 43404

Walter R. Kastenschmidt

A High School Course Integrating Statistics and Computer Programming

The goal of this project is to design, conduct, and evaluate a high school course which integrates non-calculus statistics with computer programming. The product will be an in-

structor's course guide with associated student materials, (e.g., programming exercises, statistical problems to be solved with the computer). The computer will be used for three purposes: (1) to teach programming in the BASIC language; (2) to serve as a sophisticated computational tool for statistical calculations; and (3) to display commercial statistical programs which simulate experiments too costly or too time-consuming to be conducted by high school students. As students progress through the course, they will gradually build a statistics package which can be used at the end of the course to analyze a practical problem requiring statistical treatment.

Potential outcomes of the course are projected as follows: (a) by writing and interacting with their own computer programs, students will become more knowledgeable of computer capabilities and limitations; (b) through the teaching of computer programming the student's problem-solving capabilities will be heightened by careful analysis of a problem and the steps required to complete it successfully; (c) the selection of statistical problems for computer programming will result in a more thorough understanding of the statistical concepts and formulas. Students will use self-designed computer programs to do involved calculations which, done manually, would require inordinately large amounts of time. Students thus will be able to spend more time interpreting the results of their calculations.

Award Number: SED 80-24212 (NSF/NIE)
Award Amount: $31,623
Duration: July 15, 1981—December 31, 1982

SELECTED RELATED PROJECTS SUPPORTED IN EARLIER FISCAL YEARS

In the last ten years, the Science and Engineering Education Directorate of the National Science Foundation has invested over $50 million in computer-related activities. A significant proportion of that investment was made by the Development in Science Education Program and its predecessors.

Many projects have been supported over the years; only a few of the projects which involve pre-college mathematics and computing are described here. Also several principal investigators who received awards for work on pre-college mathematics using computers in Fiscal Years 1980 and 1981 have received earlier grants to work on this topic. These earlier awards are *not* included in the following list.

Additional projects in mathematics using computing activities are discussed in *Learning Alternatives in U.S. Education: Where Student and Computer Meet*, Hunter, Beverly, et al., Educational Technology Publications, Englewood Cliffs, New Jersey 07362, 1975.

University of California, Irvine
Physics Computer Development Project
Irvine, CA 92717

Alfred Bork
Richard Ballard
Joseph Marasco

Computer Graphics in Learning

The project explored the use of interactive graphics primarily as an aid in learning beginning physics and the related mathematics.

Award Number: SED 74-20289
Award Amount: $660,933
Duration: 36 months

Stanford University
Institute for Mathematical Studies in the Social Sciences
Stanford, CA 94305

Patrick Suppes

Experimental Teaching of Mathematics in the Elementary School

Materials were produced for computer-assisted instruction for drill-and-practice in mathematics for supplementary instruction in grades 1-6 and for a tutorial computer-based curriculum in logic and algebra for grades 4-8.

Award Number: G-9173; G-18709
Award Amount: $2,285,851
Duration: 1959—1971

University of Denver
Department of Mathematics and Computer Science
College of Arts & Sciences
Denver, CO 80208

William S. Dorn

Computing and Mathematics Curriculum Project

This project developed a secondary school mathematics curriculum which integrated the use of computers.

Award Number: GJ-308 (1969)
Award Amount: $388,200
Duration: 24 months

Illinois Institute of Technology
Physics Department
Chicago, IL 60616

Harold Weinstock

Computer-Based Interdisciplinary Self-Instructional Modules

The project produced a sequence of self-contained, machine-independent, computer-oriented student study manuals at the introductory college level in chemistry, mathematics, and physics. The manuals were prepared for both students and instructors who have minimal computer expertise and whose campuses provide limited computer facilities and access.

Award Number: SED 74-14691
Award Amount: $141,214
Duration: 36 months

University of Illinois
CERL
Urbana, IL 61801

Donald L. Bitzer

Demonstration of the PLATO IV Computer-Based Education System

The main objective of the project was to implement and evaluate the PLATO IV system at the elementary, community college, and university levels. This central objective required the development and operation of programs in curriculum, system, software, and hardware development; inter- and intra-institutional coordination and liaison; systems operation, including maintenance, author/teacher training and support and communications and evaluation.

One of the curriculum development and field testing activities under this project was the production of the PLATO Elementary Mathematics materials directed by Dr. Robert B. Davis.

Award Number: C-723
Award Amount: $7,860,000
Duration: 58 months

Michigan State University
East Lansing, MI 48824

Herman D. Hughes

Impact of Microcomputers on Teaching Math and Science to Junior High School Students

This project focuses on the development of materials which make use of low-cost microcomputers for teaching basic problem-solving skills in junior high school mathematics and science.

Award Number: SED 79-19045
Award Amount: $127,300
Duration: 30 months

University of Montana
Department of Computer Science
Missoula, MT 59801

Robert P. Banaugh

Development of a Course of Study in Quantitative Methods for Natural Science Students Just Using the BASIC Language

This project developed a course of study emphasizing the formulation and solution of problems originating in the natural sciences using the BASIC language. The goal was the training of students to formulate hypotheses, to translate them into an operational computer program, and to analyze the results. Quantitative hypotheses were formulated directly into BASIC without the use of mathematics as a middle language.

Award Number: SED 74-19057
Award Amount: $105,700
Duration: June 6, 1974—September 30, 1976

Dartmouth College
Hanover, NH 03755

Donald L. Kreider
Arthur W. Luehrmann, Jr.

Computer-Based Course Materials for Introductory University Mathematics, Physics, and Engineering

This project developed a new introductory sequence of calculus courses coordinated with both a new physics and new engineering course. The overall objective of the calculus course was to integrate the use of the computer into the first two years of college mathematics.

Award Number: GJ-650 (1970)
Award Amount: $388,200
Duration: 24 months

University of Pittsburgh
Pittsburgh, PA 15260

Thomas A. Dwyer

A Computer-Based High School Mathematics Laboratory (Soloworks)

Soloworks developed a basically new approach to using technology in support of human learning. The emphasis was on the use of computers to provide flexible, highly interactive, experiential/creative worlds for learners of high school age. Project Soloworks was aimed primarily at secondary school mathematics, science, and computer science programs.

Award Number: SED 73-07321
Award Amount: $523,770
Duration: 42 months

Mitre Corporation
1820 Dolley Madison Boulevard
McLean, VA 22102

John L. Volk

Demonstration and Evaluation of the TICCIT Computer-Based Education System

The Mitre Corporation, in collaboration with Brigham Young University, developed and operated a minicomputer-based CAI system, TICCIT, designed for use by community colleges. This required the development and integration of hardware and software systems, as well as interrelationships with the college faculty and staff. Courseware was written for English and for mathematics instruction.

Award Number: C-729 (1972)
Award Amount: $5,100,000
Duration: 54 months